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Title: Non-Radiographic Diagnostics Available at DARHT

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Los Alamos NATIONAL LABORATORY

Non-Radiographic Diagnostics Available at DARHT

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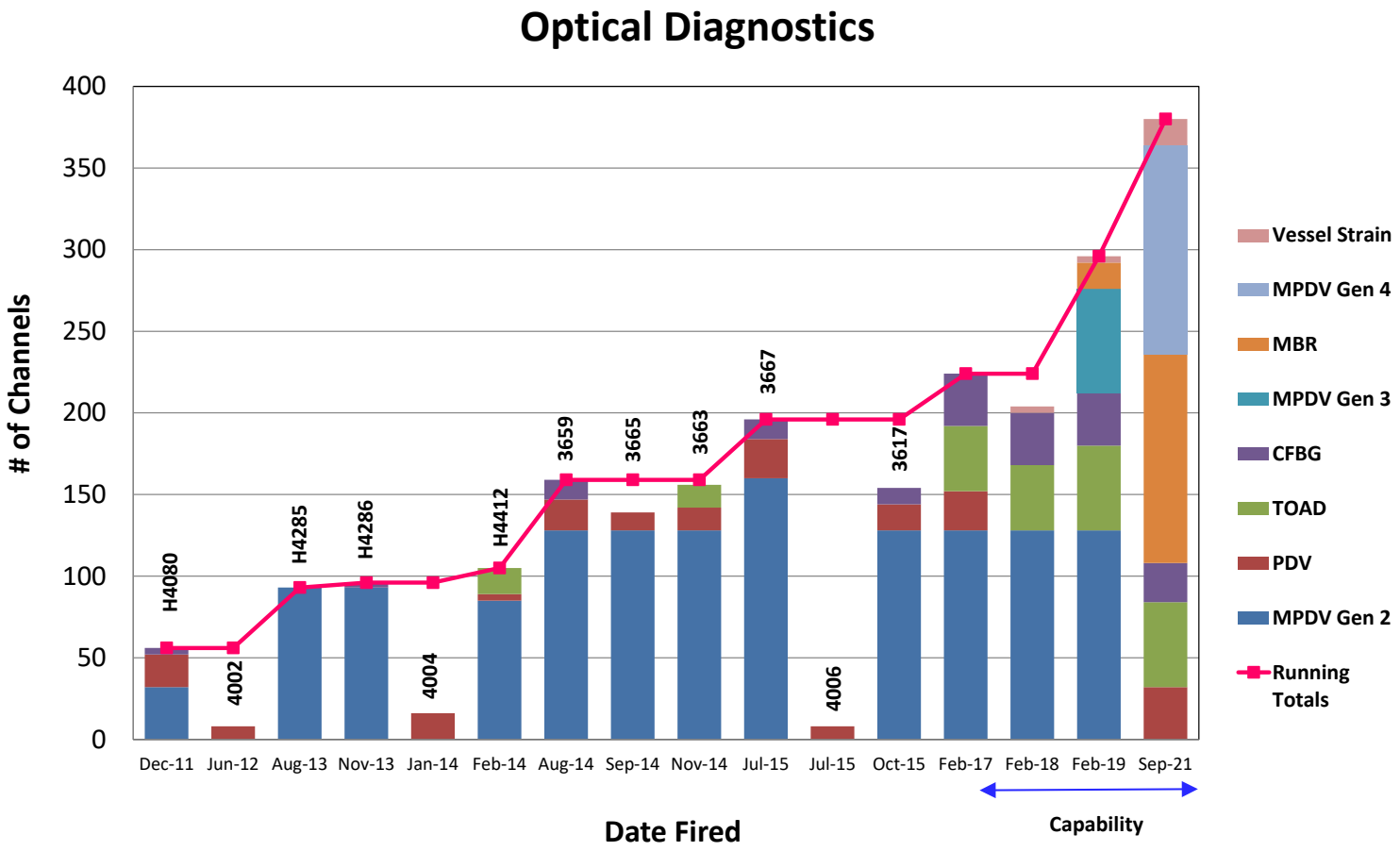
Summary of Laser / Fiber Optic-Based Diagnostic Types at DARHT

- 128 Channels of Gen IV MPDV
  - Newest version with best signal to noise.
- 128 Channels of Modulation Based Ranging (MBR)
- 52 Channels of Time of Arrival Diagnostic (TOAD)
- 24 Channels of Time Domain Chirped Fiber Bragg Grating (TD-CFBG)
- 4 types, and nominally 16 channels, of fiber optic-based vessel strain measurements
- Fiber-based temperature measurement (in development)
- Additional diagnostics can be brought in as needed:
  - PDV
  - In situ TOAD
  - Capillary TOAD
  - BLR

Excellent complement to radiographic imagery.

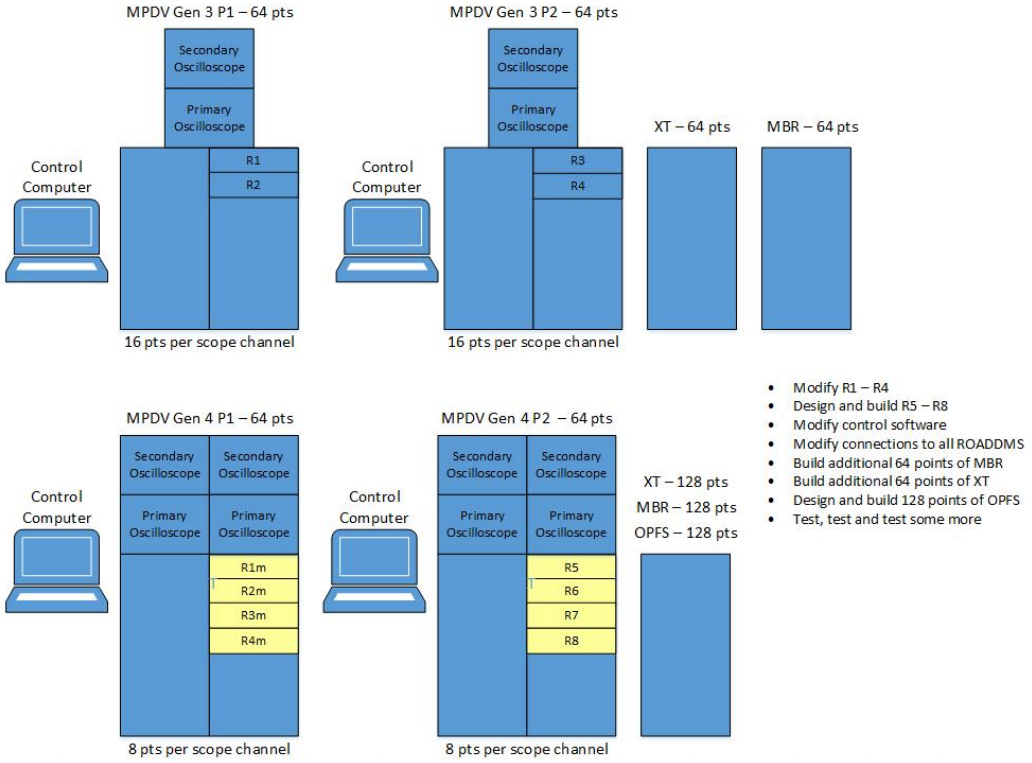
Historical Increase in Fiber-Based Diagnostic Channels



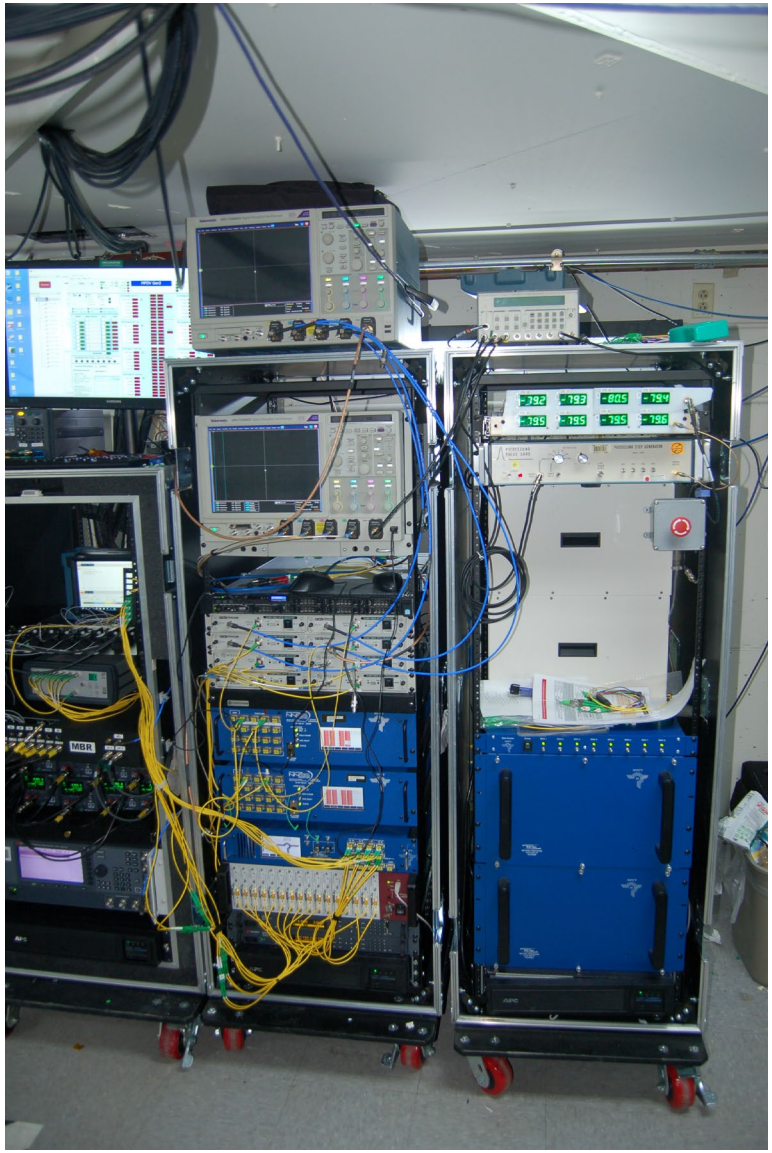
Gen IV Multiplexed Photonic Doppler Velocimetry (MPDV)

- Measures implosion velocity.
- Most capable system developed to date.
  - Construction complete by end of FY21
- 128 Channels.
- Significantly improved signal to noise compared to predecessors
  - Based on table-top prototype.
  - Use of time-multiplexed rather than wavelength multiplexed signals $\Rightarrow$ reduced competition for digitizer bits.
- Elimination of the cross talk and Stimulated Brillouin Scattering effects from the Gen III system.
- Available launch power increased from 5 mW to 200 mW per channel.
- Includes feedback stabilization of launch power based on return signal to increase dynamic range from x2 to x200.
  - Will mitigate early loss of data from laser attenuation during the experiment.
- Development, *tabula rasa*, of LANL data analysis code that treats measurement uncertainty properly.

MPDV Gen IV



MPDV – Multiplexed Photo Doppler Velocimetry, ROADDM – reconfigurable optical add-drop delay multiplexer, MBR – Microwave Based Ranging
XT – Cross timing, OPFS – Optical power feedback stabilization

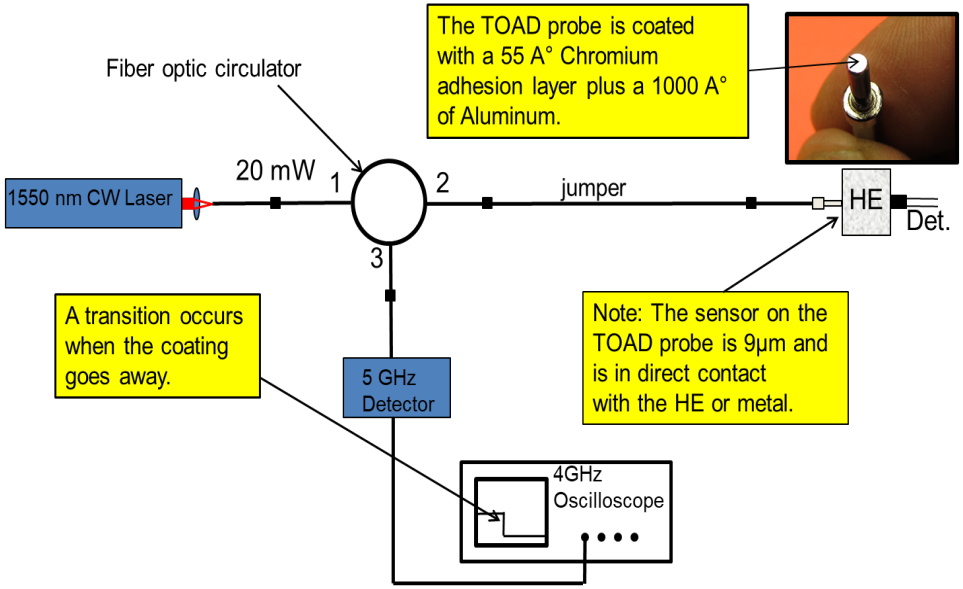


System Schematic

Existing Racks

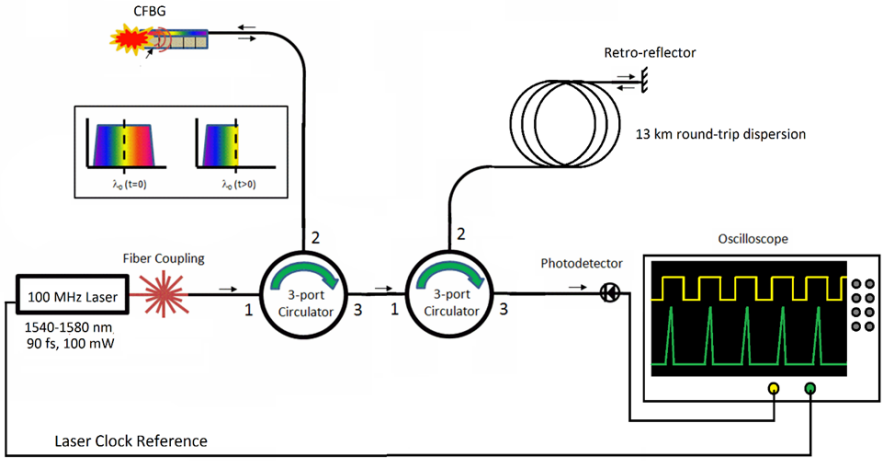
Time of Arrival Diagnostic (TOAD)

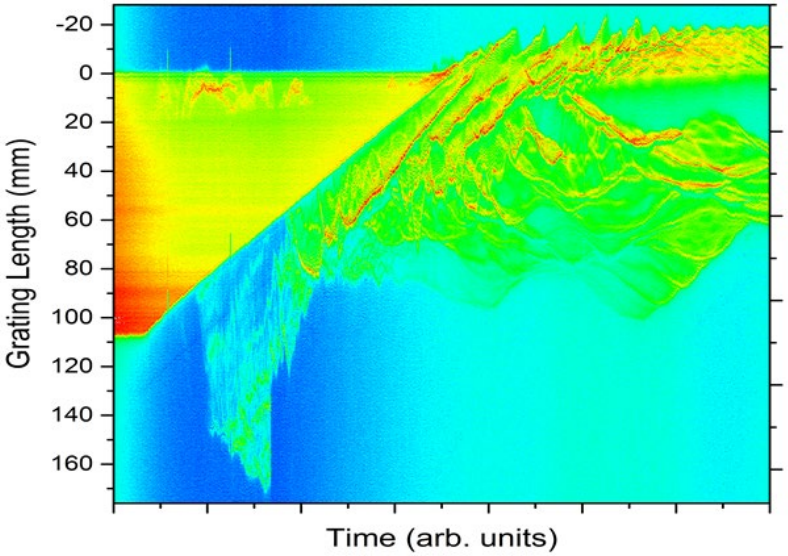
- Detonation wave arrival time accurate to 200 ps.
- Multiple variants including:
  - Jump Off PDV
  - Capillary TOAD
  - In situ TOAD
- Primary diagnostic for detonator timing measurements.
- Used for both detonator and hydrotest measurements.

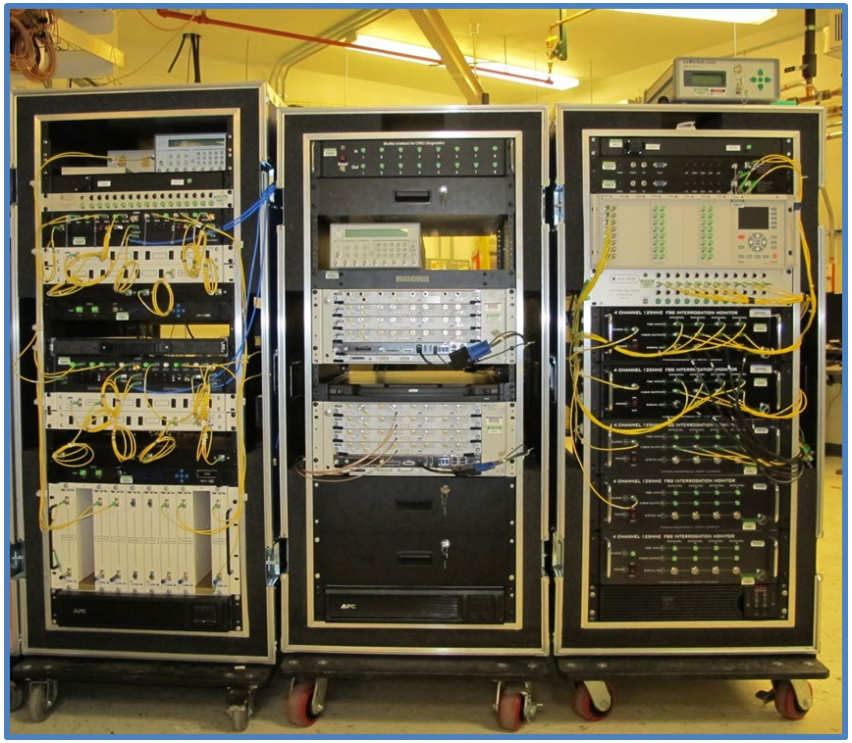


Time Domain Chirped Fiber Bragg Grating(TD-CFBG)

- Continuous measurement of detonation wave position and velocity.
- 24 Channels
- Also measures lower-amplitude shock wave spectrum.

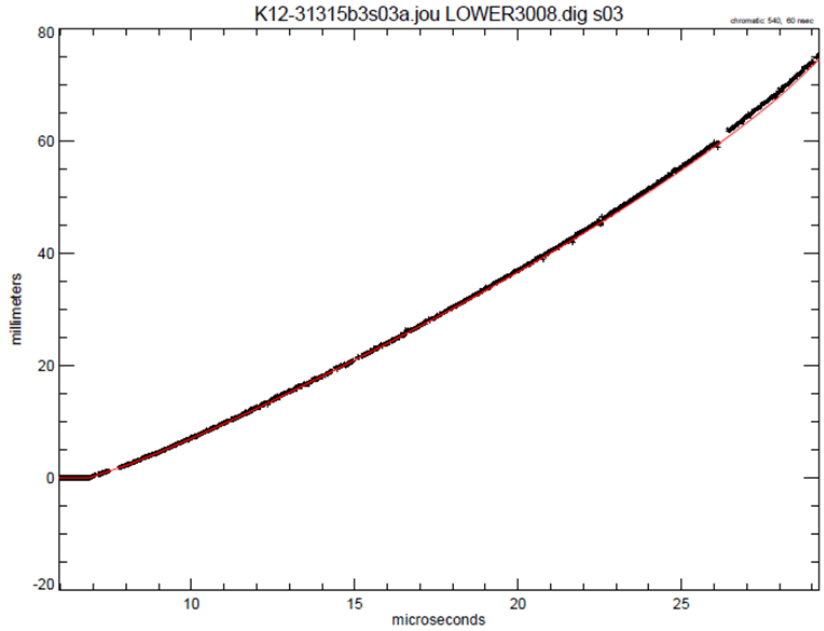


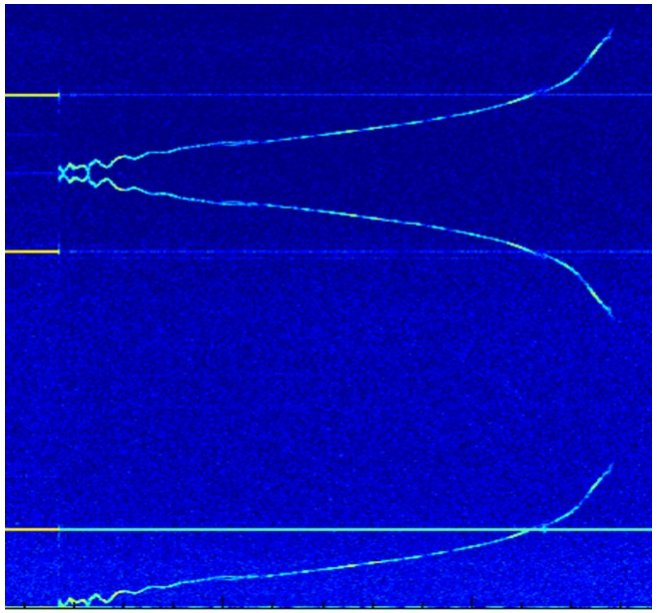




Modulation Based Ranging

- Direct measure of implosion surface position.
- Uses existing MPDV optical paths; identical beamlines.
  - ➢ Inexpensive: ~$2k / channel
- Complements MPDV: MPDV ⇒ velocity, MBR ⇒ Position.
- True 25 μm accuracy over entire measurement range. $\int$
- Consistent with MPDV. Upper plot shows MBR agreement with MPDV





Vessel Strain Measurements

- Measures strain response of vessel to impulsive load (i.e. an explosion).
- Used to monitor vessel integrity and predict vessel failure.
- 4 measurements:
  - Local and global X
  - Elastic and plastic
- 3 Measurement systems:
  - LUNA Swept Wavelength Reflectometer
  - Real Time Localized Strain (RTLS) Measurements with Fiber Bragg Gratings
  - Spectral Interferometry for Transient Strain (SITS)
- Entirely fiber-optic based
  - Faster response than electrical
  - Highly impervious to electromagnetic interference.
  - Very accurate.